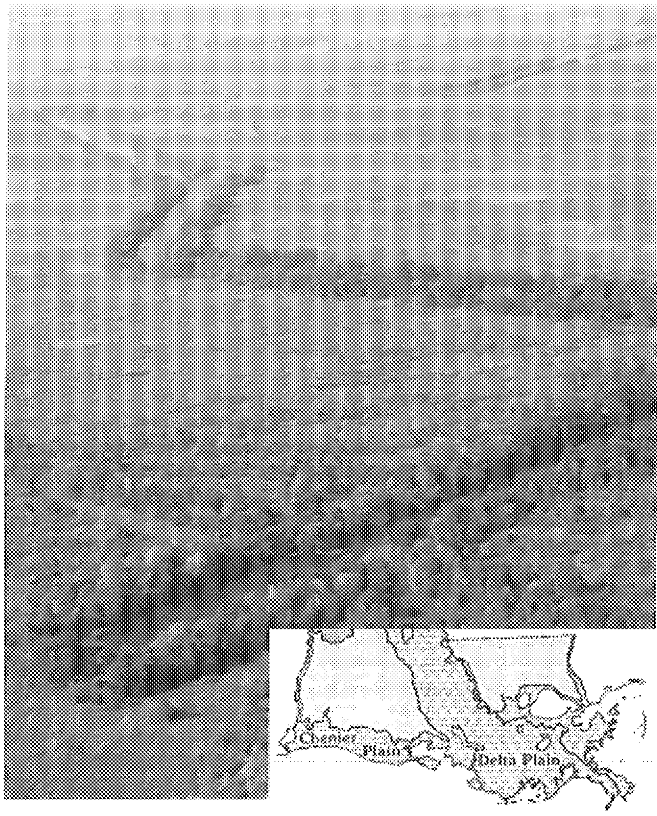
1. Introduction

The Southeast Louisiana Flood Protection Authority-East, which represents most of New Orleans and its suburbs, filed a lawsuit on 24 July 2013 against 97 oil and gas companies. The Authority was formed after Hurricane Katrina to be more isolated from politics than previously. The members are comprised of engineers and scientists and the Authority. The suit (http://slfpae.com/News Release on Coastal Land Loss 7-24-13.pdf) charges the companies with decades of unlawful neglect of damages caused to the state's wetlands, thereby resulting in flooding from hurricanes being more likely, dangerous, and expensive.

These notes are about the relationships between dredged waterways (e.g., channels, canals) and wetland loss (land loss) in coastal Louisiana.



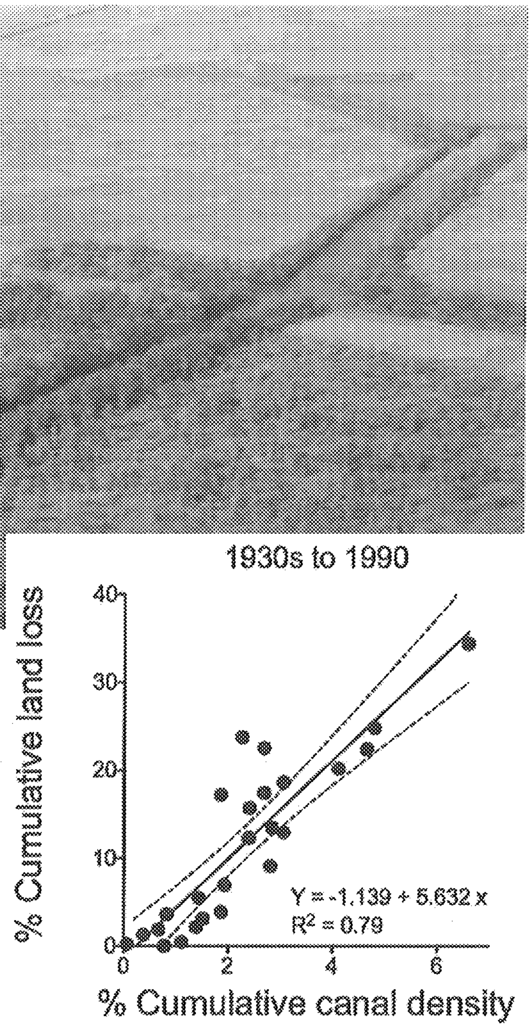


Figure 1. Canal density and land loss in the deltaic plain.
The data shown in the figure are for 15 minute quadrangle maps (roughly 164,000 acres) for the deltaic plain, except for maps with < 50% land area in the 1930s. The total area represented is 77% of the deltaic plain (4,970 sq. miles). Photo by RETurner.

2. Qualitative Observations

Examples of early observations of the qualitative effect of spoil banks and canals on the natural hydrology and land loss rates in coastal Louisiana.

"Many oil company canals, with their flanking spoil banks, cross the marsh giving rise to changes in drainage, hence, vegetation. Although the trappers of the region are probably prone to exaggerate the effects of such canals on the vegetation of their trapping lands, there can be no doubt that changes do occur as a result of their construction. In addition, artificial levees dam many streams and cause modification of drainage....Thus, relatively minor modifications in marshland drainage may create many unforeseen problems" (Van Lopik 1955, p. 36).

"In the past, pipeline canals traversed marshlands and embayments without regard for changes in natural drainage pattern. Also disregarded were resultant disruption of currents in bays and water flow in marshlands and the direct loss of animals and plants within the right-of-way. The long range effects of such canals involve accelerated erosion of unstable marshes" (St. Amant 1972, p. 388).

"Canalization of natural streams invariably alters their flow regime. In upland areas canals may change runoff characteristics, usually improving drainage. In lowlands they alter both runoff and storage and may also seriously upset natural circulation patterns and water chemistry. In general, although the effects of canals on wetland environments are more difficult to evaluate, it is likely that they are more pronounced than in upland areas" (Gagliano 1973, p. 1).

3. Measured *Direct* Wetland Losses from Canals and Spoil Banks

Canals and spoil banks cause wetland loss by the direct replacement of one habitat with another. Table 1 provides estimates of the extent of the direct impacts from canals in Louisiana. The total area impacted can be significant. A typical oil and gas canal is dredged to be about 4 to 5 m deep and 41 to 45 m wide, which is much wider and deeper than a natural channel in coastal marshes. Baumann and Turner (1990) estimated that approximately 16.1 percent and 6.3 percent of the wetland loss in coastal Louisiana from 1955/6 to 1978 was from the combined effect of canals and spoil banks, or canals alone, respectively. Britsch and Dunbar (1993) estimated that the 45,866 ha of man-made channels dredged from the 1930s to 1990 (in slightly different mapping units from Baumann and Turner 1990) accounted for 12 percent of the total land loss during that interval.

Summary: 'Direct' wetland losses

Direct effect of canals	6.3 to 12 %
Direct effect of canals and spoil banks	16.3 %

4. Measured *Indirect* Land Losses from Canals and Spoil Banks

The *direct* impact of canal dredging accounts for about 16 percent of wetland loss in Louisiana's coastal zone (Table 4.1). The remaining 84 percent of wetland loss is from other causes, including the *indirect* impacts of canals, which is widely acknowledged. The specific mechanisms to explain these impacts are not fully understood in each marsh type or estuary. One of the indirect impacts on wetlands is waterlogging, which results from the damming effect of spoil banks above- and below-ground. Spoil banks compact the soil beneath them (Nichols 1959), thereby reducing below-ground water flows (Swenson and Turner 1987). Waterlogged soils stress plants and may reduce the accumulation of soil organic matter. The spoil bank and canal also alter the patterns of waterflow, e.g., frequency of flooding and drying. Spoil banks also may inhibit sedimentation rates in some cases (Cahoon and Turner 1989). The combined effects of canals and spoil banks lead to enhanced soil subsidence rates and plant stress culminating in land to water conversion that can extend out up to 2 km from the canal (Turner and Rao 1990).

There are several estimates of these indirect losses of land or wetland. (1) A consensus estimate by 13 coastal scientists is that, from 1955/6 to 1978, the combined direct and indirect impacts of canals caused *at least* 30 to 59 percent of the total coastal land loss in Louisiana (Turner and Cahoon 1997). (2) Scaife et al. (1983) used data plots of the density of canals vs. the land loss from 1955 to 1978 to estimate the background rate of land loss from all other factors in the absence of canals. Their estimate of the land loss from canals could then be calculated as the difference in the loss rates minus this background rate. The resulting estimate for the deltaic plain was that 89% of the land loss was due to the direct and indirect effects of canals and the associated spoil banks. (3) Penland et al. (1996; an unpublished report) provided a subjective estimate that canals were the cause of 35 percent of the wetland losses for this coast. (4) Turner (1997) presented an analysis suggesting that the best explanation among four competing hypotheses explaining the wetland loss in coastal Louisiana was the hypothesis that the combined effects of the direct and indirect impacts of canals and spoil banks caused these land losses (and not subsidence, river levees, salinity stress, or sediment starvation). (5) Day et al. (2000), in contrast, suggested that the coastwide effects of canals on land loss was limited to 9.2 percent, which is about equal to the direct effect – i.e., that there were no indirect impacts. Although these estimates are not in complete agreement, it is clear that a significant wetland area lost along this coast is attributable to the combined direct and indirect impacts of canals and spoil banks.

<u>Summary: Total land loss from canals and spoil banks (Direct and Indirect losses)</u>

a) 89%	Scaife et al. 1983; based on data for deltaic plain
b) minimum 30 to 59 percent	Turner and Cahoon 1987
c) 35%	Penland et al. 1996; - a *subjective* estimate
d) 9.2%	Day et al. 2000; note – this estimate equals the amount from the direct impact, i.e., they say there are *no* indirect impacts
e) >95%	Figure, page 1; adapted from data discussed in Turner 1997

Table 1. *Estimates of the direct wetland loss from canals and spoil banks in Louisiana from 1955/6 to 1978 (from data in Baumann and Turner 1990).*

A. Dimensions	1978
A1. Canal	
total area	36,593 ha
average width [1]	40.9 m
average length	8,947 km
A.2. Spoil Bank	
total area	43,833 ha
average width [2]	24.5 m
average length [2]	17,894 km
area spoil bank : area canal	1.2 ha : ha
A.3. Total Wetland Area	1,126,398 ha
A.4. Canal + Spoil Bank	
total area (ha)	80,426 ha
total area as percent of wetland Area	7.1%

B. Change	1955/6 to 1978
B.1. Wetland Loss	288,414 ha
B.2. Increase in open water	225,690 ha
B.3. Canal	
increase	18,110 ha
canal increase as a proportion of wetland loss	6.3%
B.4 Spoil	
increase	28,245 ha
spoil bank increase as a proportion of wetland loss	9.8%
B.4. Canal + Spoil Bank	
canal + spoil bank increase	46,355 ha
canal + spoil bank increase as a proportion wetland loss	16.1%

[1] Canals identified on 65 U.S. Fish and Wildlife Service (USFWS) 7.5-minute quadrangle maps for 1955/6 and 1978 were measured, all of which are in coastal Louisiana. The average canal width was 45.4 and 40.9 m in 19955/6 and 1978, respectively.

[2] Spoil banks are usually built on both sides of the canal.

Figure 2. Intracoastal Waterway near Houma

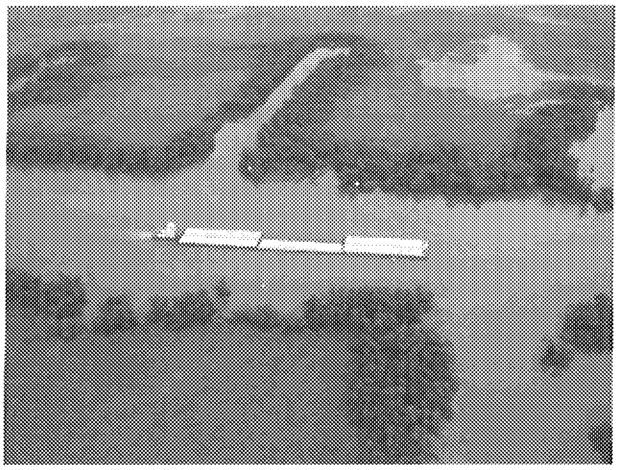
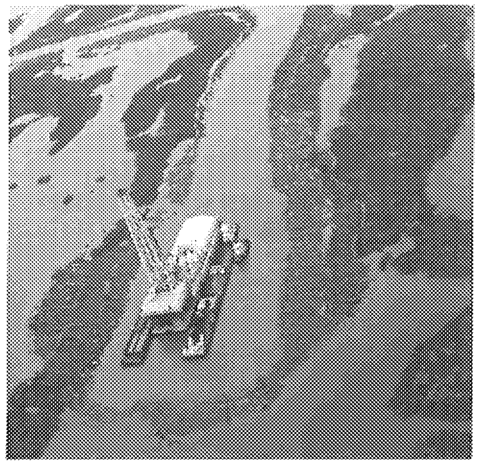


Figure 3. Dredging south of Houma



Photos by RETurner

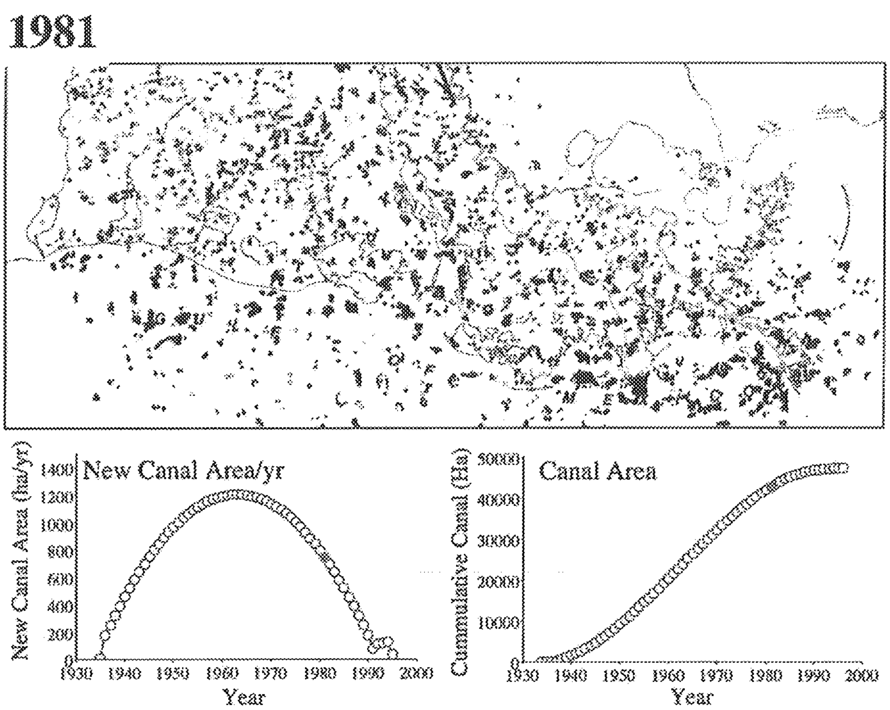


Figure 4. The rise in canal area, 1900 to 2000
The distribution of oil and gas fields in south Louisiana circa 1981 and the increase in canal area in the last century. The map is adapted from the Louisiana Geological Survey maps. The two data diagrams are adapted from data discussed in Turner (1997).

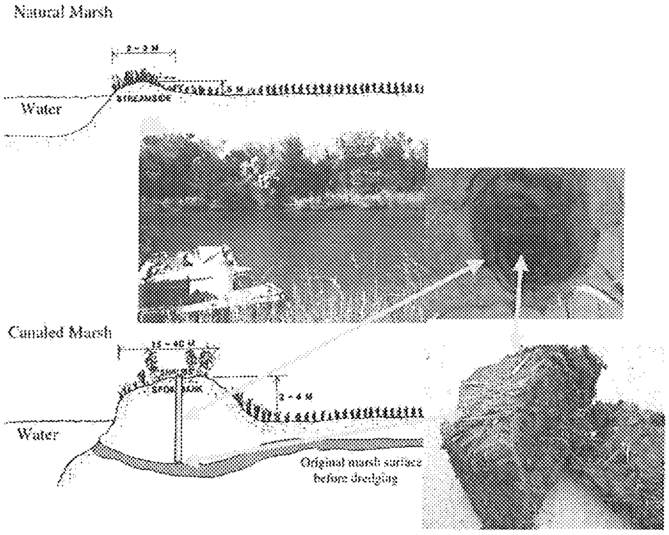


Figure 5. X-section of a canal in the Terrebonne estuary
A comparison of a natural stream channel (top) and dredged canal (bottom). A hole was dug through the top of the spoil bank to locate the original marsh surface. Note that the original marsh surface is depressed below the spoil bank. Adapted from Turner and Streever (2001).

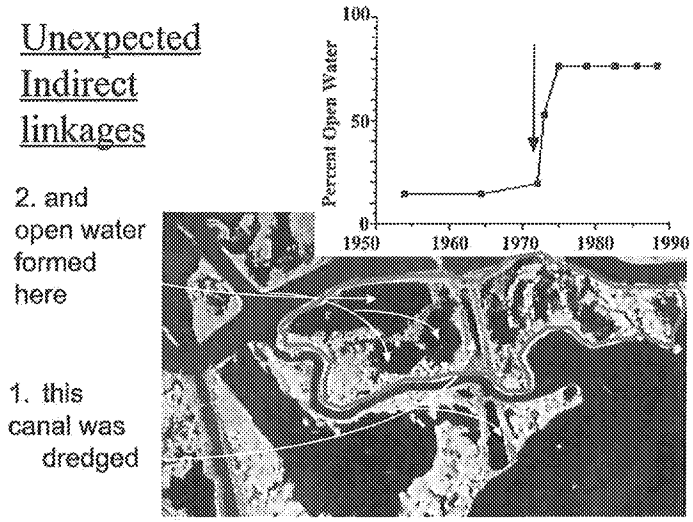


Figure 6. Immediate changes @ one location
A canal was dredged on the south side of Jug Lake, west of Houma. The area of adjacent marsh went from around 15% open water to 85% open water within 2 years after dredging. Adapted from Turner et al. (1994).

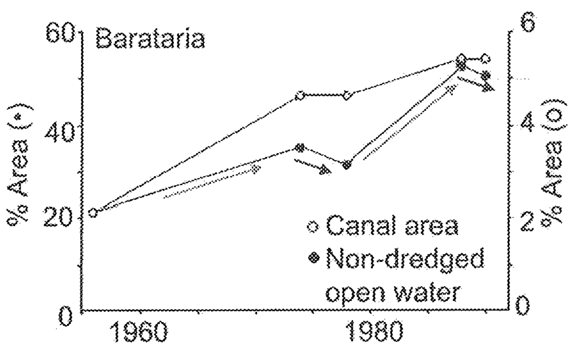


Figure 7. 'Dose-response' changes in three estuaries
The area of mash converting to open water in the Barataria estuary (exclusive of canal area) and the area of canal. There was an increase in open water when dredging increased (two times), and a slight decline when dredging ceased (two times). There are similar examples for the Breton Sound and Terrebonne estuaries. Adapted from Bass and Turner (1997).

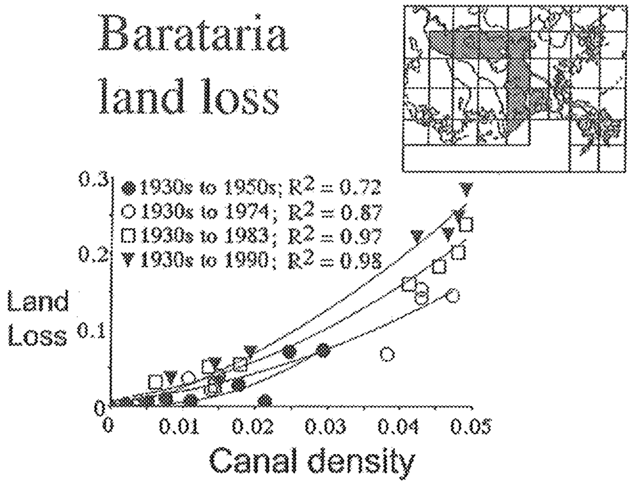


Figure 8. Temporal changes in the Barataria estuary
The relationship between canal density and land loss in the Barataria Bay estuary for different intervals from the 1930s to 1990 (in 15 min. quadrangle maps). Note (1) the zero intercept when canal density is zero, and (2) the increased amount of land loss per area of canal (increased slope) in later years. Adapted from data discussed in Turner (1997).

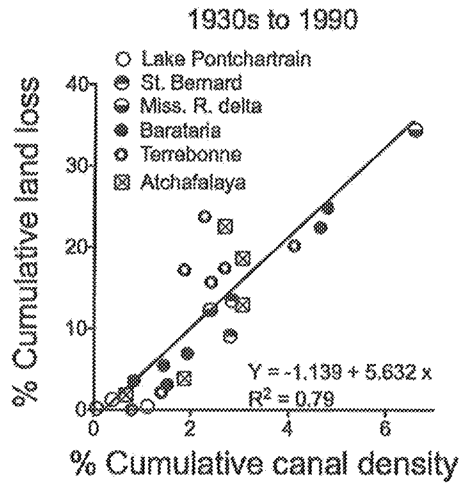


Figure 9. Changes in canal density and land loss for the deltaic plain estuaries
The relationship between canal density and land loss for the deltaic plain (15 min quadrangle maps) from the 1930s to 1990. Note the zero intercept. Adapted from data discussed in Turner (1997).

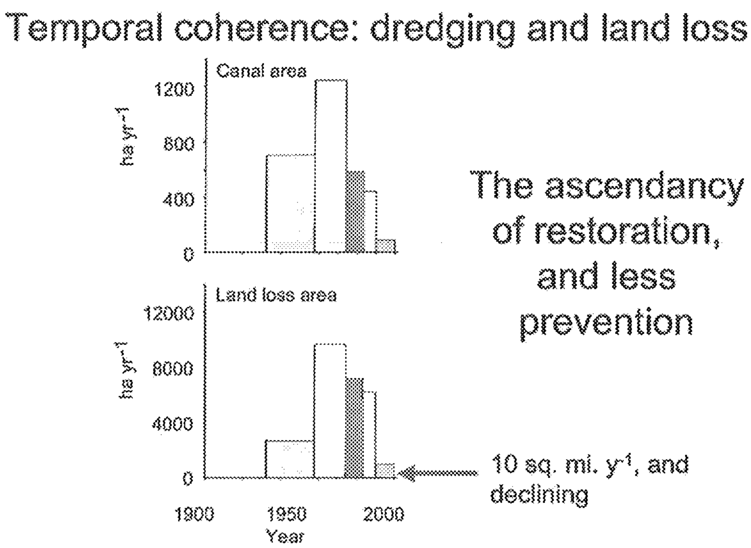


Figure 10. Temporal Changes for the entire coast
There is a temporal coherence of dredging and land loss for the Louisiana coast from the 1930s to 2001. Land loss rose and declined with dredging. Adapted from data discussed in Turner (1997).

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